Would Border Carbon Adjustments prevent carbon leakage and heavy industry competitiveness losses? Insights from a meta-analysis of recent economic studies

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Abstract

The efficiency of unilateral climate policies may be hampered by carbon leakage and competitiveness losses. A widely discussed policy option to reduce leakage and protect competitiveness of heavy industries is to impose Border Carbon Adjustments (BCA) to non regulated countries, which remains contentious for juridical and political reasons. The estimation of carbon leakage as well as the assessment of different policy options led to a substantial body of literature in energy-economic modeling.

In order to give a quantitative overview on the most recent research on the topic, we conduct a meta-analysis on 25 studies, altogether providing 310 estimates of carbon leakage ratios according to different assumptions and models. The typical range of carbon leakage ratio estimates are from 5% to 25% (mean 14%) without policy and from -5% to 15% (mean 6%) with BCA. The output change of Energy Intensive Trade Exposed (EITE) sectors varies from -0.1% to -16% without BCA and from +2.2% to -15.5% with BCA.

A meta-regression analysis is performed to further investigate the impact of different assumptions on the leakage ratio estimates. The decrease of the leakage ratio with the size of the coalition and its increase with the binding target is confirmed and quantified. Providing flexibility reduces leakage ratio, especially the extension of coverage to all GHG sources. High values of Armington elasticities lead to higher leakage ratio and among the BCA options; the extension of BCA to all sectors is in the meta-regression model the most efficient feature to reduce the leakage ratio. Our most robust statistical finding is that, all other parameters being constant, BCA reduces leakage ratio by 6 percentage points.

Keywords: Carbon leakage, Competitiveness, Border Carbon Adjustments, Meta-analysis, Meta-regression analysis, Computable General Equilibrium (CGE) models.

Les Ajustements Carbone aux Frontières empêcheraient-ils les fuites de carbone et les pertes de compétitivité pour les industries lourdes ? Éclairages à partir d'une méta-analyse d'études économiques récentes

Résumé

L'efficacité des politiques climatiques unilatérales pourrait être réduite par les fuites de carbone et les pertes de compétitivité. Une option politique largement débattue pour réduire les fuites de carbone et protéger la compétitivité des industries lourdes est d'imposer des Ajustements Carbone aux Frontières (ACF) aux pays non contraints, ce qui reste controversé pour des raisons juridiques et politiques. L'estimation des fuites de carbone comme l'évaluation des différentes options politiques a conduit à de nombreuses études dans le domaine de la modélisation énergie-économie.

Afin de donner une vue d'ensemble de la recherche la plus récente sur le sujet, nous conduisons une méta-analyse de 25 études, représentant au total 310 estimations de taux de fuites de carbone selon différentes hypothèses et modèles. La plage de variation type des estimations de taux de fuites de carbone sont de 5% à 25% (moyenne 14%) sans politique et de -5% à 15% (moyenne 6%) avec ACF. Le changement de production des secteur Énergie-Intensifs et Exposés au Commerce International (EIECI) varient de -0.1% à -16% sans ACF et de +2.2% à -15.5% avec ACF.

On effectue ensuite une méta-régression pour déterminer plus en détail l'impact des différentes hypothèses sur les estimations de taux de fuites de carbone. La diminution du taux de fuites avec la taille de la coalition et son augmentation avec la cible de réduction est confirmée et quantifiée. Proposer des mécanismes de flexibilité réduit le taux de fuites de carbone, particulièrement lorsque tous les gaz à effets de serre (et pas seulement le CO_2) sont couverts. Des valeurs élevées d'élasticité d'Armington conduisent à un taux de fuites plus élevé et parmi les options d'ACF, l'extension des ACF pour tous les secteurs est dans la méta-régression la caractéristique la plus efficace pour réduire le taux de fuites de carbone. Notre résultat le plus robuste statistiquement est que, toutes choses égales par ailleurs, les ACF réduisent le taux de fuites de carbone de 6 points de pourcentage.

Mots-clés : Fuites de Carbone, Compétitivité, Ajustements Carbone aux Frontières, Méta-Analyse, Méta-Régression, modèles d'Équilibre Général Calculable.

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Abstract

The efficiency of unilateral climate policies may be hampered by carbon leakage and competitiveness losses. A widely discussed policy option to reduce leakage and protect competitiveness of heavy industries is to impose Border Carbon Adjustments (BCA) to non regulated countries, which remains contentious for juridical and political reasons. The estimation of carbon leakage as well as the assessment of different policy options led to a subsantial body of litterature in energy-economic modeling.

In order to give a quantitative overview on the most recent research on the topic, we conduct a meta-analysis on 25 studies, altogether providing 310 estimates of carbon leakage according to different assumptions and models. The typical range of carbon leakage estimates are from 5% to 25% (mean 14%) without policy and from -5% to 15% (mean 6%) with BCA. The output change of Energy Intensive Trade Exposed (EITE) sectors varies from -0.1% to -16% without BCA and from +2.2% to -15.5% with BCA.

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1. Introduction

International climate agreements are likely to remain sulglobal in the years to come: the global climate architecture is shifting from a UNFCCC-led top-down regime to a bottom-up approach (Rayner, 2010). Differences in Abatement targets among countries may lead to two dinstinct but interrelated issues: carbon leakage and competitiveness losses, especially among Energy Intensive Trade Exposed (EITE) sectors, such as Cement, Steel or Aluminium (Dröge et al., 2009). Indeed, the asymmetry of carbon costs between regions may induce a shift of production of carbon intensive products from carbon-constrained countries to less carbon-constrained countries. As carbon dioxyde is a global pollutant, i.e. the geographic location of emissions has no influence on its environmental impacts, this carbon leakage would reduce the environmental effectiveness of the climate policies. Moreover, these production losses in heavy industries would also damage the economy and involve job destructions.

Carbon leakage and competitiveness issues have been one of the main arguments against the implementation of ambitious climate policies. A growing body of academic litterature has been

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developped in the recent years to quantify the impacts of uneven climate policies and to find the best policy measures to counteract them. Among them, Border Carbon Adjustements (BCA), which consists in taxing products at the border on their carbon content, are widely discussed. Their WTO consistency as well as their political consequences remain highly contentious among legal Experts: they could constitute an incentive to join the climate coalition or trigger a trade war because of green protectionnism suspicions.

Ex post econometrical studies haven't revealed so far any evidence of carbon leakage (Reinaud, 2008; Ellerman et al., 2010; Quirion, 2011; Sartor, 2013) predicted in analytical models (Fischer and Fox, 2011; Jakob et al., 2011; Hoel, 1996; Markusen, 1975). *Ex ante* modeling are dominated by Computable General Equilibrium (CGE) (Böhringer et al., 2012a) models but there are also some sectoral partial equilibrium models (Mathiesen and Moestad, 2004; Monjon and Quirion, 2011b). Some litterature reviews have been published recently on the subject (Zhang, 2012; Quirion, 2010; Dröge et al., 2009; Gerlagh and Kuik, 2007) but to our knowledge no quantitative meta-analysis has been made.

Meta-analysis is a method developped to provide a summary of empirical results from different studies and test hypotheses regarding the determinants of these estimates (Nelson and Kennedy, 2009). It has been extensively used in medical research. The first meta-analysis in economics can be traced back to Stanley and Jarell (Stanley and Jarrell, 1989). In the field of environment and resource economics, the majority of meta-analyses summarize the results of different nonmarket valuation studies (Van Houtven et al., 2007; Brander and Koetse, 2011; Barrio and Loureiro, 2010; Ojea and Loureiro, 2011; Richardson and Loomis, 2009). Closer to our subject, one can cite two studies on marginal Abatement costs to mitigate climate change, one for all sectors (Kuik et al., 2009) and the other specific to agriculture (Vermont and De Cara, 2010). An extensive review of meta-analysis methods in environmental economics is given in Nelson and Kennedy (Nelson and Kennedy, 2009).

In this article, we conduct a meta-analysis on 25 studies dating from 2004 to 2012, altogether providing 310 estimates of carbon leakage according to different assumptions and models. The typical range of carbon leakage estimates are from 5% to 25% (mean 14%) without policy and from -5% to 15% (mean 6%) with BCA. We then do a meta-regression analysis to further investigate the impact of different assumptions on computed results. Our model Explains 51% of the variance, which suggests that variability between the models remains significant. Impact of key model parameters, such as Armington elasticities, and policy features such as Linking carbon markets or extending pricing to all GHG sources can be highlighted. We found that, all other parameters being constant, BCA implementation reduces leakage ratio by 6 percentage points.

The remainder of this paper is structured as follow. Section 2 decribes the database and section 3 provides some descriptive statistics. The meta-regression model is Explained in section 4 and results are discussed in section 5. Section 6 concludes.

2. Database description

The selection of studies for a meta-analysis is a decisive matter. Publication bias is a form of sample selection bias that occurs if primary studies with statistically weak or unusual results are less likely to be published (Nelson and Kennedy, 2009). For example, it has been widely recognized to exagerage the effectiveness of pharmaceuticals (Doucouliagos and Stanley, 2009). In our case, as we deal with model studies (no statistical significancy is involved), we believe that the publication bias is less important than for statistical studies (especially in medical studies). However a publication bias may remain for studies with unusual results[1]. Statistical techniques to take this bias into account exist (Stanley, 2005; Rothstein et al., 2006) but only for statistical studies. Our best option to address this issue was to embrace as many studies as possible without artificially setting aside some of them, e.g. non peer-reviewed papers.

[1]Authors compare their results with those of the litterature and are able to change the settings or calibration of their models to influence the results. Model comparisons may involve then a convergence of model results.

Many articles and working papers deal with carbon leakage and competitiveness issues but only some of them are models giving *ex ante* numerical estimates. The body of litterature regarding these issues also comprises *ex post* econometrical analyses, analytical models and political or juridical studies (Cosbey et al., 2012; Ismer and Neuhoff, 2007; Monjon and Quirion, 2011b). The criteria to be part of our sample was first to provide numerical estimations of carbon leakage with a model. The second criteria was, since the purpose of this paper is to investigate the impact of Border Carbon Adjustments on leakage, to include BCA in the scenarios. To constitute our sample, we searched for studies in standard search engines (Web of Science, Google Scholar, etc) and cross references. Our sample is made of 25 studies dating from 2004 to 2012, most of them (14) are part of the recent Energy Economics Special Issue. Some are grey litterature (MIT working paper, World Bank working paper, etc), others are published in environmental economics journals (Energy Economics, Energy Policy, the Energy Journal, Energy Policy, Climate Policy etc). The majority are Computable General Equilibrium (CGE) models relying on the GTAP database (except for one), the others are sectoral or multi-sectoral partial equilibrium models. The number of carbon leakage estimates per study varies from 2 (Weitzel et al., 2012) to 54 (Alexeeva-Talebi et al., 2012a), with a mean of 12.6. The way to deal with "within studies/between studies" variability is a major source of concerns for meta-analysis. In the next sections we'll Explain how we deal with it for descriptive statistics and meta-regression.

The common use of the leakage-to-reduction ratio or leakage ratio,

$$l = \frac{\triangle E_{NonCOA}}{- \triangle E_{COA}}$$

where $\triangle E_{COA}$ is emissions variation in the climate coalition between the climate policy scenario and the counterfactual business-as-usual scenario, avoids us to make approximate conversions between studies. In other words all studies calculate the same thing, which is necessary in a meta-analysis as a "synthesis requires the ability to define a common concept to be measured" (Smith and Pattanayak, 2002)).

In the majority of the cases results were available on tables, but sometimes they were taken from graphs or derived from own calculation (Mattoo et al., 2009).

3. Descriptive Statistics

3.1. First sight

Figure 1 presents ranges of leakage ratio estimates for the 25 studies (mean, minimum and maximal values with or without BCA). Leakage ratio estimates range from 2% to 41% without BCA and from -41% to 27% with BCA. Eight studies find negative values of leakage ratio in case of BCA, with three studies (Mathiesen and Moestad, 2004; McKibbin et al., 2008; Lanzi et al., 2012) finding values below -15%. Internal variations (within one study) of leakage ratio estimates range from almost null (Alexeeva-Talebi et al., 2012b) to relatively high (Mathiesen and Moestad, 2004; Bednar-Friedl et al., 2012; Ghosh et al., 2012) depending on the scenarios and models.

Comparing scenarios by pair (with and without BCA, all the other parameters being constant), we can observe that in all cases, BCA led to a reduction of the leakage ratio[2]. These results are in constrast with (Jakob et al., 2011) who found that BCA could increase leakage ratio[3]. For each pair, we calculate the leakage ratio reduction in percentage points (defined as $LeakageRatioReduction = LeakageRatio_{NoBCA} - LeakageRatio_{BCA}$). In the majority of the cases, the leakage ratio reduction due to BCA stands between 1 and 15 percentage points, but

[2]In figure 1, for FF2012 (Fischer and Fox, 2011), the mean with BCA is higher than with no BCA. but the "equivalent" BCA scenarios corresponds to the highest value of leakage ratio of the no BCA scenario (Europe only abating).

[3]In this paper, under certain conditions, if in non coalition countries, the carbon intensity of Exports ("clean" sector) is higher than those of local production ("dirty" sector), a reallocation of production induced by BCA from "clean" to "dirty" sector would increase emissions in non coalition countries and then leakage ratio on a global scale

there are some outliers above 30 percentage points, where BCA actually generates negative leakage ratios (McKibbin et al., 2008; Mathiesen and Moestad, 2004).

Apart from carbon leakage, competitiveness losses in energy-intensive industries constitutes the other component of the climate trade nexus. Though extensively used in the public debate, the notion of competitiveness remains ambiguous (Alexeeva-Talebi et al., 2012b). Some authors consider that this notion is meaningless at the national level (Krugman, 1994). At the sectoral level, it may refer to "ability to sell" or "ability to earn". In CGE models, competitiveness is most of the time implicitely defined as "ability to sell" and measured by gross output. In our sample, 17 of the 25 studies show results of output change for industries. Based on GTAP sectors, EITE sectors often regroups Refined goods, Chemical products, Non-metallic minerals, Iron and Steel Industry and Non-ferrous metals (although sometimes Refined goods is aside). Some studies present only disaggregated results by sectors, and not the output change for EITE sectors as a whole. In this case, we use the average of the output of Iron and Steel and Non Metallic Minerals sectors (or average of Iron and Cement) as a proxy for EITE sectors[4].

The output change of EITE sectors varies from -0.1% to -16% without BCA and from +2.2% to -15.5% with BCA. There is a clear dichotomy between CGE models where output loss range is 0%-3% (except for Alexeeva-Talebi 2012 (b) and Ghosh et al. 2012 where it's a bit more (around 3%-7%)) and sectoral partial equilibrium models where output loss range is 8%-15%. In all cases, BCA reduce the output loss among EITE industries[5] and in five cases (Peterson and Schleich, 2007)(Alexeeva-Talebi et al., 2012b; Kuik and Hofkes, 2010; Mattoo et al., 2009; Ghosh et al., 2012), the output variation of EITE industries is even positive.

The welfare (or in some studies GDP) variation of the abating coalition ranges from -1.58% to 0.02% without BCA and from -0.9% to 0.40% with BCA (the environmental impact is never taken into account in the welfare estimation[6]). Though BCA improve welfare of coalition countries compared to a no BCA scenario, they most of the time don't reestablish a "neutral" situation (e.g a variation near 0%), contrary to previously with the output of EITE industries. The welfare variation is still negative after BCA, because the consumers of the coalition pay higher prices in EITE sectors' products. This improvement of welfare in coalition countries goes hand in hand with a bigger degradation of welfare in non coalition countries. BCA have big distributionnal impacts: they transfer a part of the burden to the non coalition countries (Böhringer et al., 2012c). In the studies that report it (Böhringer et al., 2012c; Lanzi et al., 2012; Mattoo et al., 2009), *global* welfare is decreasing with BCA.

3.2. Merging studies

Gathering all the estimates of carbon leakage in the 25 studies, we compute kernel density estimations for the estimates accross all studies. As the number of estimates varies greatly (from 2 to 54) accross studies, we consider two ways of merging results, the "scenarios equality" method and the "articles equality" method. In the "scenarios equality" method, we add all estimates regardless of the article they are from. Then an article with N estimates "weights" $N/2$ times more in the final distribution than an article with only two estimates. In the "articles equality" method however, weights are put on estimates to assure that each article "weights" the same in the final distribution[7]. By this process the distribution of results with the "articles equality" method is less smooth because there are artificially some accumulation in the distribution. However the

[4]For the only two studies where output changes were available both by sector and for EITE sectors as a whole (Lanzi et al., 2012; Ghosh et al., 2012), it was a correct proxy. Iron and Steel (resp. Non Metallic Minerals) being a bit less (resp. more) impacted than EITE as a whole

[5]However in the CASE model (Monjon and Quirion, 2011a,b), cement output is more reduced in the presence of BCA

[6]In the Energy Economics special issue, leakage is endogenously compensated by a higher Abatement to assure a same environmental impact in all scenarios in order to compare welfare variations

[7]If N_k is the number of estimates in the article k, the weight for an estimate from article i is then $\frac{\max_k(N_k)}{N_i}$ (and the closest integer value for kernel estimate using Stata). In this case each article weights $\max_k(N_k)$ in the final distribution.

distributions share the same shape with both results, especially for the leakage ratio and the output variation of EITE industries, which can be interpretated as a sign of the robustness of the results.

Both leakage ratio distribution and EITE output change distribution are bimodal. For leakage ratio without BCA there is a concentration around 5% and another around 12%[8]. We can see that a leakage ratio above 100%, theoretically possible if the carbon content of products is higher outside the climate coalition is well out of the range of estimates in the litterature. For EITE output variation there is a concentration at -2% and another one (more spread out) at -7% (the dichotomy CGE models/PE models). The coalition welfare variation distribution is unimodal, with a mode of -0.6% without BCA and -0.3% with BCA.

One can easily visualize in figures 6 and 7 the impact of BCA in reducing leakage ratio, restoring some competitiveness and to a lesser extent improving coalition welfare with the left shift of the leakage ratio distribution and the right shifts of the output change and coalition welfare change distributions.

[8]Not a single estimate of leakage ratio is negative without BCA, the negative part is an artifact in the kernel density estimation

Table 1: Selected studies (En. Eco.=Energy Economics, WP=Working Paper)

Name	Reference	Journal	Model Name	Model type	Main Database	Cluster	Obs
Boh2012	(Böhringer et al., 2012a)	En Eco (SI)	Several	CGE	GTAP 7.1	1	28 (15+13)
Gho2012	(Ghosh et al., 2012)	En Eco (SI)	EC-MS-MR	CGE	GTAP 7.1	7	18 (6+12)
AT2012	(Alexeeva-Talebi et al., 2012a)	En Eco (SI)	PACE	CGE	GTAP 7.1	2	54 (27+27)
Lan2012	(Lanzi et al., 2012)	En Eco (SI)	ENV-Linkages	CGE	GTAP 7.0	3	44 (20+24)
Boh2012-2	(Böhringer et al., 2012b)	En Eco (SI)	BCR	CGE	GTAP 7.1	8	18 (9+9)
BalR2012	(Balistreri and Rutherford, 2012)	En Eco (SI)	MINES	CGE	GTAP 7.0	13	10 (5+5)
Wei2012	(Weitzel et al., 2012)	En Eco (SI)	DART	CGE	GTAP 7.0	13	2 (1+1)
FF2012	(Fischer and Fox, 2011)	En Eco (SI)	GTAPinGAMS	CGE	GTAP 7.0	10	5 (4+1)
BB2012	(Boeters and Bollen, 2012)	En Eco (SI)	WorldScan	CGE	GTAP 7.0	14	9 (3+6)
Spr2012	(Springmann, 2012)	En Eco (SI)	CVO	CGE	GTAP 7.1	11	7 (4+3)
Car 2012	(Caron, 2012)	En Eco (SI)	CEPE	CGE	GTAP 7.0	11	8 (4+4)
Bed2012	(Bednar-Friedl et al., 2012) et al.	En Eco (SI)	WEG_CENTER	CGE	GTAP 7.0	4	24 (12+12)
Boh2012-3	(Böhringer et al., 2012c)	En Eco (SI)	SNOW	CGE	GTAP 7.1	12	10 (1+9)
Ant2012	(Antimiani et al., 2012)	En Eco (SI)	GTAP-E	CGE	GTAP 7.1	10	3 (1+2)
Mat2009	(Mattoo et al., 2009)	World Bank WP	ENVISAGE	CGE	GTAP 7.0	9	6 (1+5)
McKW2009	(McKibbin et al., 2008)	Lowy Institute WP	G-Cubed	CGE	n.a	9	4 (2+2)
PS2007	(Peterson and Schleich, 2007)	ISI Working Paper	GTAP-E	CGE	GTAP 6.0	15	6 (2+4)
KH2010	(Kuik and Hofkes, 2010)	Energy Policy	GTAP-E	CGE	GTAP 6.0	10	3 (1+2)
Win2011	(Winchester et al., 2011)	MIT Working Paper	EPPA	CGE	GTAP 6.0	9	5 (1+4)
BabR2005	(Babiker, 2005)	The Energy Journal	No Name	CGE	GTAP 5.0	12	2 (1+1)
MM2004	(Mathiesen and Moestad, 2004)	The Energy Journal	SIM	PE		6	11 (9+2)
MQ2011-1	(Monjon and Quirion, 2011a)	Ecological Economics	CASE II	PE		5	20 (10+10)
DQ2005	(Demailly et al., 2005)	OECD Report	CEMSIM-GEO	PE		6	3 (1+2)
DQ2008	(Demailly and Quirion, 2008)	Energy Economics	CASE I	PE		6	6 (3+3)
MQ2011-2	(Monjon and Quirion, 2011b)	Climate Policy	CASE II	PE		5	6 (2+4)

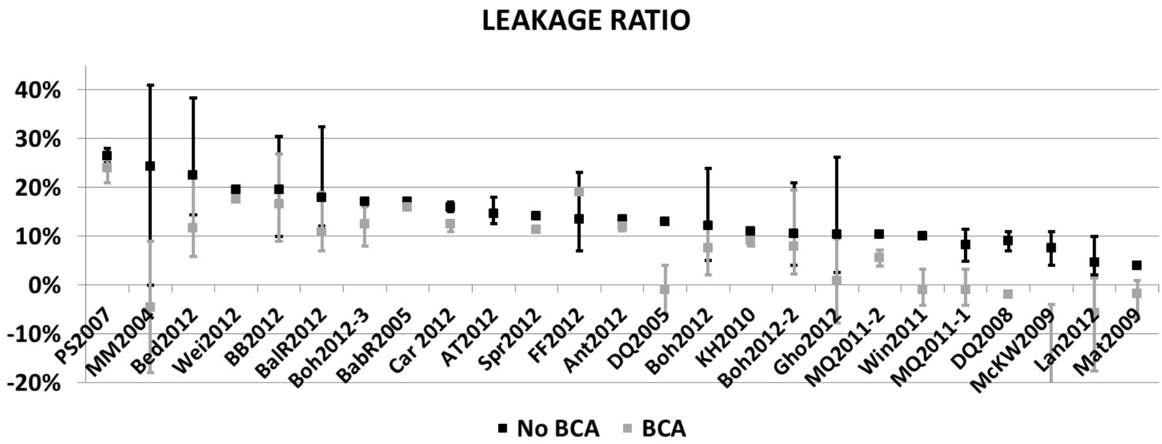

Figure 1: Leakage ratio in selected studies (mean, minimum and maximal values with or without BCA), ranked by mean value without BCA

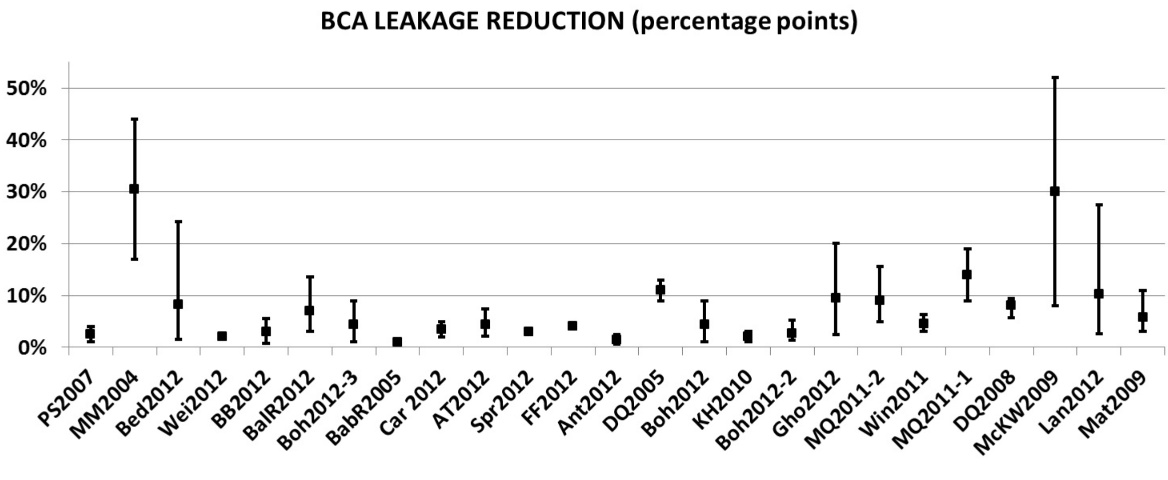

Figure 2: Leakage ratio reduction in case of Border Carbon Adjustment (same ranking as in figure 1)

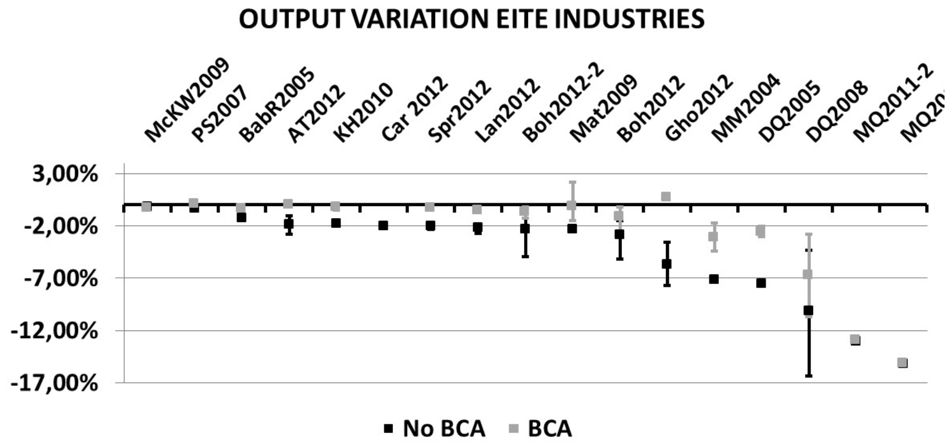

Figure 3: Output change of EITE industries in selected studies (ranked by mean value without BCA)

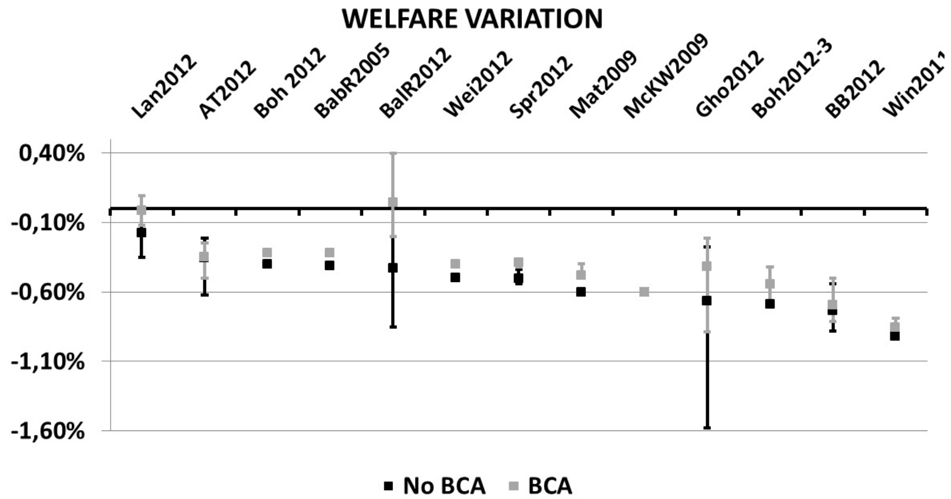

Figure 4: Welfare variation in abating coalition (ranked by mean value without BCA)

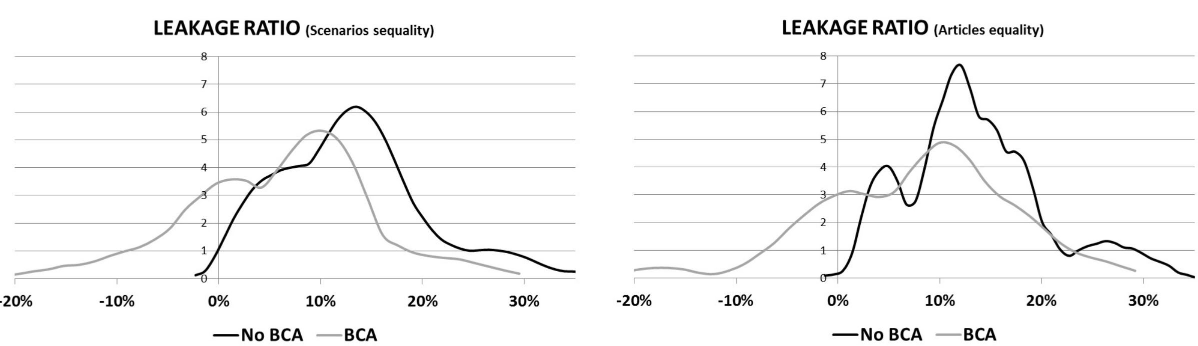

Figure 5: Leakage ratio (Kernel density estimates) with the two methods of merging, “scenarios equality” and “articles equality”

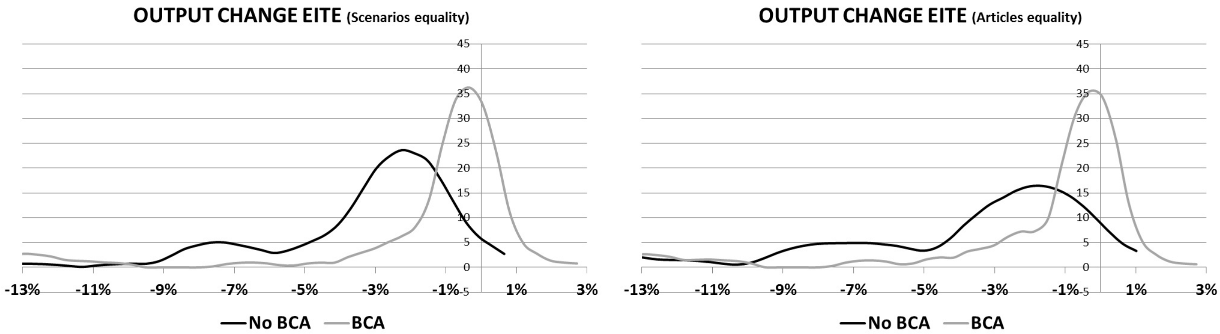

Figure 6: Output change of EITE industries (Kernel density estimates) for two cases. scenarios equality and articles equality

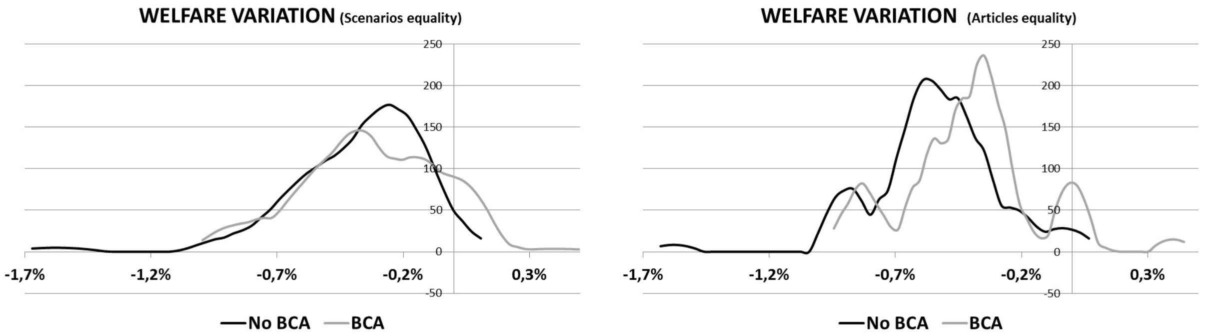

Figure 7: Welfare variation (Kernel density estimates) for two cases. scenarios equality and articles equality

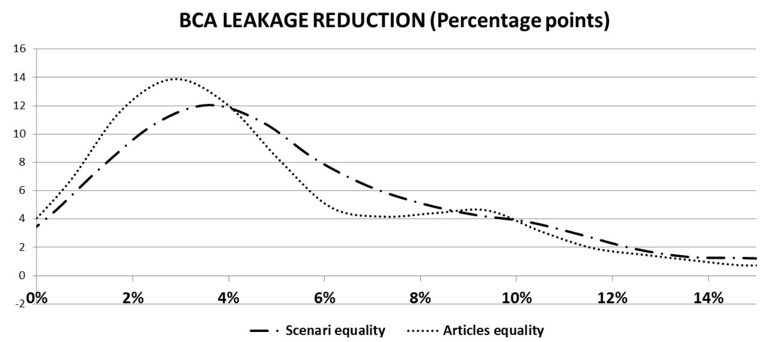

Figure 8: BCA leakage reduction (in percentage points)

4. Meta-regression: the model

Meta-regression is widely used in meta-analysis as it is an interesting way to go beyond standard litterature review by combining numerical results from different studies in a statistical manner (Vermont and De Cara, 2010; Kuik et al., 2009; Horváthová, 2010). Several econometric problems occurs during this exercice: data heterogeneity, outliers, heteroskedasticity in effect size variance, non independance of observations of the same primary studies (Nelson and Kennedy, 2009).

Hetereroskedasticity in effect size variance is usually treated by weighting observations by the inverse of variance estimations or sample size (Van Houtven et al., 2007). As we deal with simulation model results and not statistical studies results this method is irrelevant. One may think that among all studies some are more relevant or better than others and should then be weighted more, but we think that putting weights based on the "quality" of the studies would have been too arbitrary. Heterogeneity is addressed with the use of methodological and hypotheses variables in the meta-regression and by attemps to avoid a publication bias as discussed above.

Regarding the non independance of observations of the same primary studies, some authors favor the use of a single estimate per study (Stanley, 2001) but this shrinks dramatically the pool of estimates. In our case we treat this issue with a "cluster-robust" estimator based on Huber and White (Huber, 1967; White, 1980) (as in (Kuik et al., 2009; Vermont and De Cara, 2010)): the observations are gathered in 15 clusters (see table 1). Studies with many observations are the first clusters[9], then studies that share common features are gathered in same clusters (2 or 3 studies per cluster representing 10-15 observations)[10].

To treat outliers, we have developped a routine based on the rreg Stata command, which performs a robust regression using iteratively reweighted least squares. First we make a robust regression using this algorithm and keep the final weights. Then we dismiss data that are weighted below a certain threshold (5%)[11]. Finally we make a cluster-robust regression on this reduced sample. We show both results (with and without dismissing outliers) in table 3 and one can see that, with only about 10% of data in the sample dismissed, outliers-free results are much more significant.

We test three variations of the two models: one for all leakage ratio estimates, one for no BCA estimates and the last one for BCA estimates:

$$\begin{aligned} Leakage = \quad & Const + \beta_1 GE + \beta_2 Coasize + \beta_3 Abatement + \beta_4 Link \\ & + \beta_5 Offset + \beta_6 GHG + \beta_7 Armington + \beta_8 BCA + u \end{aligned}$$

$$\begin{aligned} Leakage_{NoBCA} = \quad & Const + \beta_1 GE + \beta_2 Coasize + \beta_3 Abatement + \beta_4 Link \\ & + \beta_5 Offset + \beta_6 GHG + \beta_7 Armington + u \end{aligned}$$

$$\begin{aligned} Leakage_{BCA} = \quad & Const + \beta_1 GE + \beta_2 Coasize + \beta_3 Abatement + \beta_4 Link \\ & + \beta_5 Offset + \beta_6 GHG + \beta_7 Armington + \beta_9 Exp \\ & + \beta_{10} Foreign + \beta_{11} AllSect + \beta_{12} Indirect + u \end{aligned}$$

The first variables used are *GE* (a dummy variable set equal to 1 if the model is a CGE). *Coasize* (the size of the abating coalition in percentage of worldwide emissions). *Abatement* (the

[9] With the exception of (Monjon and Quirion, 2011a,b) which are merged because results are from the same model CASE II

[10] We tested different clusters without significant changes. Results are available upon demand

[11] Several values were tested and 5% was the best compromise to have significant results without dismissing too many values. 21 out of the 25 studies had less than one result dismissed and 2 studies had a significant share of dismissed results (Mathiesen and Moestad, 2004; Peterson and Schleich, 2007) which have relatively high estimates of leakage ratio).

Abatement target)[12]. Then we have three dummy variables related to scenarios *Link* (if permit trading is authorized between the different regions of the coalition[13]). *Offset* (if Offset credits are authorized) and *GHG* (if all carbon sources, and not only CO2 are considered).

Armington elasticities, which are used to model international trade, are considered as a crucial parameter in leakage ratio estimates (Monjon and Quirion, 2011a; Alexeeva-Talebi et al., 2012a; Balistreri and Rutherford, 2012). Most of the time they were not Explicitely displayed in the articles. However some studies made sensitivity analyses on this parameter (for example doubling or dividing in half the original values). In the meta-analysis, the *Armington* parameter is then not a numerical value but an "almost dummy" Linked with "high" (+1), "low" (-1), "very high" (+2) or "very low" (-2) Armington elasticities values[14] when sensitivity analysis were performed on these parameters. It would have been interesting to incorporate a parameter for the fossil fuel supply elasticity which is recognized to be determinant in the leakage ratio estimations for the international fossil fuel channel (Light et al., 1999; Gerlagh and Kuik, 2007). However, because they weren't available most of time, it was decided not to take them into account in the meta-regression.

BCA is another dummy which takes the value of 1 if BCA is implemented and four dummy parameters detail the policy features of the BCA: *Exp* (if Export rebates are part of the scheme), *Foreign* (if the adjustement if based on foreign specific emissions, instead of home specific emissions or best available technology). *AllSect* (if the adjustment concerns all sectors and not only EITE sectors), and *indirect* (if indirect emissions are taken into account in the adjustment). Table 2 summarizes information about the regression variables.

[12]The logarithm of *Coasize* and *Abatement* have been tried as variables without changing the statistical significancy of the results

[13]which supposes that the abating coalition is composed of more than one region in the model

[14]In (Balistreri and Rutherford, 2012) the Melitz structure (Melitz 2003) is considered equivalent to "very high" Armington

Table 2: Variables of the Meta-regression

Name	Variable type	Explanation	Summary statistics
GE	Dummy	1 if the model is a CGE	268 (87% of the cases)
Coasize	Percentage	Size of the abating coalition (percentage of worldwide emissions)	Mean 35% Mode: 15% (for 39% of the cases)
Abatement	Percentage	Abatement target	Mean 19% Mode: 20% for 61% of the cases
Link	Dummy	Possibility to sell permits accross the coalition	83 (27% of the cases)
Offset	Dummy	Possibility to use Offsets to meet the Abatement target	18 (6% of the cases)
GHG	Dummy	If carbon pricing is extended to all GHG sources	9 (3% of the cases)
Armington	5 values (-2/-1/0/1/2)	1 (resp. -1) corresponds to "Armington high" (resp. "Armington low"). 2 for "Melitz" or higher Armington than "Armington high"	31 for 1 and 37 for -1 (10% and 12% of the cases)
BCA	Dummy	1 if there is Border Carbon Adjustment	167 (54% of the cases)
Exp	Dummy	1 if export rebates are part of the scheme	146 (87% of the BCA cases)
Foreign	Dummy	1 if the adjustment is based on foreign specific emissions (or average foreign), 0 if home (or BAT)	114 (68% of the BCA cases)
AllSect	Dummy	1 if the adjustment concerns all sectors and not specifically Energy-intensive sectors	47 (28% of the BCA cases)
Indirect	Dummy	1 if indirect emissions are taken into account in the adjustement	152 (91% of the BCA cases)

5. Discussion of the results

Interpreting the results, one must bear in mind that, though meta-regression analysis is a powerful tool to incorporate all the sources of variability in a single model, one should not give excessive credit to the results. Indeed, the calcultated coefficients depends both on primary models that made different assumptions but also on the statistical variability of the parameters which is, except for the variable BCA, far from being perfect. For example *Abatement* is set at 20% for 61% of the cases and varies within two studies only (Böhringer et al., 2012a; Demailly and Quirion, 2008). *Indirect* is set at the value 1 for 91% of the cases and varies within two studies only (Böhringer et al., 2012c; Monjon and Quirion, 2011b). This aspect is unavoidable in a meta-regression analysis as we take already made studies and don't design the scenarios by ourself. We still include these "poorly variable" variables in the regression, knowing that despite statistical methods designed to capture the slighest statistical effects, they may not appear as statistically significant as they may have been or that the value of the coefficients may be biased.

The meta-regression Explains respectively 29%, 20% and 48% of the variance in the leakage ratio estimation in the standard model (for All, No BCA estimates and BCA estimates) and 46%, 47% and 60% without outliers. The relatively higher values of the outlier-free models (where roughly values of (Peterson and Schleich, 2007) and (Mathiesen and Moestad, 2004) are dismissed) indicate that estimates of recent models are converging. However the share of unExplained variability (mainly due to differences between models) remains high: about half of the variability in the estimates can't be Explained in our meta-regression model. In the following, we will discuss the results of the outlier-free model (in terms of numerical values) because results are more significant. However, these results don't depart notably from the standard model and roughly the same conclusions could be made with the standard model results but with less statistical significancy.

The difference between CGE models and other models is statistically significant and is positive. We find that, all other parameters being constant, leakage ratio without BCA policy is 6 percentage points higher in CGE models and a bit less than the double under BCA policy, which is a noteworthy difference. The lack of non CGE models estimates (they constitute only 13% of studies) must remind us to interpret these results with caution. An Explanation could be that CGE models include both channels of leakage ratio, the competitiveness channel and the international fossil fuel channel, which is recognized to predominate (Gerlagh and Kuik, 2007; Fischer and Fox, 2011; Weitzel et al., 2012) whereas partial equilibrium models only include the first one (except for (Mathiesen and Moestad, 2004)).

The coefficient for the coalition size is positive and statistically significant. Changing the size of the coalition from Europe (15% of world's emissions in 2004) to Annex 1 plus China except Russia (71% of world's emissions in 2004) would involve in the model a decrease of leakage ratio of about 7 percentage points.

Theoretically, the bigger is the Abatement, the higher is the leakage in absolute terms (tons of carbon emissions). As the leakage ratio is the leakage in absolute terms divided by the Abatement and this latter increases as well, there is an indeterminacy about the relationship between the Abatement and the leakage ratio. In the meta-regression model, the correlation is positive, but the statistical significancy is weak. In (Alexeeva-Talebi et al., 2012b) (which was not included in our study because there was no BCA), the correlationship is negative (leakage of 32%, 29% and 27% for Europe abating respectively 10%, 20% and 30% of its emissions). In (Böhringer et al., 2012b) however, the relationship is positive (leakage of 15.3%, 17.9% and 21% for Europe abating respectively 10%, 20% and 30% of its emissions).

Concerning the policy parameters, authorizing permit trading (Linking) is not statistically significant, but the use of Offset credits as well as extending carbon pricing to all GHG sources is. All other parameters being fixed, the use of Offset credits would reduce the leakage ratio by about 8 percentage points (but the coefficient isn't statistically significant when there are BCA), which is the same order of magnitude for the effect of taxing all GHG sources.

The Armington parameter proves statistically significant for All and no BCA leakage ratio estimates and is positive as Expected. A higher value, meaning a more "flexible" international trade modeled, induces more impact of price differentiation accross regions on trade flows, and therefore more leakage ratio. In our meta-regression model, taking high values of Armington elasticities instead of low values would then lead to leakage ratio estimates about 2x1.7=3.4 percentage points higher.

With a very high p-value, we find that the BCA parameter is statistically significant and is negative. All other parameters being constant, BCA implementation reduces the leakage ratio by 6.3 percentage points. This statistical finding fits the data in the descriptive statistics section (figure 8). More specifically, among the BCA options, including all sectors instead of only EITE sectors would have the most important impact (decrease of 10.7 percentage points of the leakage ratio) followed by the inclusion of export rebates (decrease of 4.1 percentage points) and basing adjustement on foreign specific emissions instead of home specific emissions (decrease of 2.7 percentage points). In this meta-regression model it is then the BCA option with high administrative costs (adjustment to all sectors) rather than the politically and juridically risky options (export rebates and especially foreign carbon content based adjustment) that would be the most efficient to reduce leakage. The inclusion of indirect emissions is without surprise not statistically significant (there are very little statistical variability for this parameter). In the two studies where this feature is included in the scenarios, it is proven to reduce leakage: in (Böhringer et al., 2012a), from 0.5 to 2 percentage points, depending on the adjustment level (Böhringer et al., 2012c), and in (Monjon and Quirion, 2011a), from 1.5 to 2 percentage points.

Meta-regression results can also be used to make out-of-sample predictions, which is called benefit transfer (Nelson and Kennedy, 2009; Van Houtven et al., 2007). This exercice is especially interesting for meta-analysis of empirical studies as they allow forecast for other locations or commodities which may save the employed ressources to make additional surveys. Here we show as an example the results of leakage ratio estimations with the meta-regression analysis coefficients for different abating coalitions and policies (see table 4). The estimated values of leakage ratio seem reasonable but the 95% confidence intervals are wide.

Table 3: Meta-regression Results

	All	Outliers-free	No BCA	Outliers-free	BCA	Outliers-free
GE	0.042	0.087	0.004	0.059	0.107	0.106
	(1.09)	(8.04)***	(0.26)	(4.32)***	(2.95)**	(6.84)***
Coasize	-0.056	-0.141	-0.010	-0.126	-0.113	-0.139
	(0.82)	(6.08)***	(0.27)	(5.02)***	(2.82)**	(4.62)***
Abatement	0.124	0.084	0.062	0.273	0.117	0.207
	(0.32)	(0.93)	(0.40)	(2.23)**	(0.30)	(1.60)
Link	0.007	0.015	-0.015	0.012	0.036	0.020
	(0.30)	(1.54)	(0.90)	(0.76)	(1.59)	(1.61)
Offset	-0.079	-0.078	-0.080	-0.072	0.024	0.020
	(3.94)***	(6.04)***	(3.30)***	(6.54)***	(0.58)	(1.06)
GHG	-0.083	-0.078	-0.066	-0.052	-0.059	-0.054
	(4.73)***	(4.65)***	(2.32)**	(3.54)***	(2.58)**	(2.31)**
Armington	0.019	0.017	0.030	0.027	0.003	0.005
	(3.43)***	(2.74)***	(3.08)***	(6.58)***	(0.88)	(0.57)
BCA	-0.081	-0.063				
	(4.83)***	(9.22)***				
Exp					-0.073	-0.041
					(2.59)**	(2.79)***
Foreign					-0.021	-0.027
					(1.16)	(2.71)***
AllSect					-0.115	-0.107
					(2.95)**	(9.37)***
Indirect					0.005	0.002
					(0.20)	(0.09)
Constant	0.103	0.084	0.134	0.062	0.077	0.048
	(1.60)	(4.70)***	(4.32)***	(2.95)**	(1.06)	(1.83)*
R^2	0.29	0.46	0.20	0.47	0.48	0.60
N	310	293	144	131	166	160

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Abating coalition	Europe	A1xR	A1xR+China
No BCA (a)	17% (7% 27%)	12% (1% 24%)	10% (-3% 22%)
"light" BCA (b)	7% (-10% 23%)	6% (-16% 21%)	0% (-20% 19%)
"strong" BCA (c)	0% (-21% 21%)	-4% (-27% 19%)	-7% (-31% 17%)

A1xR: Annex 1 without Russia
(a) estimation with the "All" model
(b) estimation with the "BCA" model. *AllSect* = 1 only
(c) estimation with the "BCA" model. *AllSect* = 1. *Foreign* = 1 and *Exp* = 1

Table 4: Leakage ratio estimations by the meta-regression model (20% Abatement target)

6. Conclusion

A global climate policy is unlikely to be implemented in the years to come and the adoption of ambitious national or regional climate policies is hindered by claims of industry competitiveness losses and carbon leakage. Border Carbon Adjustment (BCA) has been proposed to overcome these hurdles but its potential efficacy has been controversial. Moreover some authors argue that BCA aims at protecting heavy industries competitiveness rather than at tackling leakage (Kuik and Hofkes, 2010) while other authors defend that BCA implementation cannot be justified only for competitiveness motives (Cosbey et al., 2012). Finally, BCA proposals differ by key design choices such as the coverage of exports and imports or only of imports, the inclusion of indirect (electricity-related) emissions, or the adjustment level, which can be the domestic or foreign average specific emissions, or best-available technologies. How BCA performance would be impacted by these choices remains an open question.

To shed some light of these issues, we have gathered and analysed 310 estimates of carbon leakage and output loss in Energy-Intensive Trade-Exposed (EITE) sectors from 25 studies dating from 2004 to 2012. A meta-regression is then conducted to capture the impact of different assumptions on the model results.

Across our studies, the leakage ratio ranges from 5% to 25% (mean 14%) without BCA and from -5% to 15% (mean 6%) with BCA. The main contribution of this article is that BCA does reduce the leakage ratio with robust statistical significance: all parameters in the meta-analysis being constant, the ratio drops by 6 percentage points with the implementation of BCA. In most CGE models some leakage remains after BCA implementation, which is not the case with partial equilibrium (PE) models. The most likely Explanation is that in CGE models, a part of leakage is due to the international fossil fuel price channel which is unaffected by BCA, while most PE models do not feature this leakage channel.

Concerning output loss for EITE industries, results are in sharp contrast to results about leakage: CGE models predict loss in a range from 0% to 4% (mean 2%) without BCA while PE models foresee more than the double. BCA corrects for the output loss in CGE models but less so in sectoral models. The Explanation seems that in PE models, a higher output loss is due to a drop in demand for CO2-intensive materials, loss which is mitigated by BCA.

The features of BCA (coverage, level of adjustment, etc.) are of the highest importance for the WTO consistency, feasibility, and political acceptability. The purpose of the meta-regression was also to assess their impact on competitiveness and leakage. In the meta-regression, the inclusion of all sectors in the scheme appears to be the most efficient feature to reduce leakage ratio, followed by the inclusion of export rebates and adjustment level based on foreign carbon content. Yet one can guess, in the case of hypothetical BCA implementation, that political and juridical aspects will be the more determinant and that only a “light” version (adjustment based on best available technologies, probably without the inclusion of indirect emissions) is likely to see the light of day.

Besides, the importance of the coalition size and the Abatement target are statistically confirmed and quantified: the smaller the abating coalition and the more stringent the cap, the bigger the leakage ratio. Policy features providing where and what flexibility (the possibility of Offsets and extension to all greenhouse gases) reduce the leakage ratio.

Finally, this meta-analysis confirms the importance of Armington elasticities in the leakage ratio estimation, a result crucial in terms of uncertainty analysis. This calls for more transparency and sensitivity analyses regarding these parameters in future studies.

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7. Annex

Table 5: Summary statistics for studies. Leakage Ratio

	No BCA					BCA				
	Mean	Range	Med	Std	Obs	Mean	Range	Med	Std	Obs
Boh2012	12.2%	(5.0% 23.9%)	12%	5%	15	7.5%	(2.0% 12.0%)	8%	3%	13
Gho2012	10.4%	(2.5% 26.2%)	8%	9%	6	0.8%	(-7.8% 9.5%)	7%	5%	12
AT2012	14.6%	(12.6% 18.0%)	14%	2%	27	10.0%	(9.8% 10.9%)	10%	0%	27
Lan2012	4.4%	(2.0% 9.1%)	4%	2%	20	-6.2%	(-21.0% 4.1%)	-2%	8%	24
Boh2012-2	10.5%	(4.0% 21%)	9%	6%	9	7.9%	(2.3% 19.4%)	5%	7%	9
BalR2012	17.9%	(12% 32.5%)	14%	9%	5	10.8%	(7.0% 19.0%)	9%	5%	5
Wei2012	19.5%	(19.5% 19.5%)	20%	0%	1	17.5%	(17.5% 17.5%)	18%	0%	1
FF2012	13.5%	(7.0% 23.0%)	12%	7%	4	19.0%	(19.0% 19.0%)	19%	0%	1
BB2012	19.5%	(10.0% 32.5%)	18%	9%	3	16.5%	(8.9% 26.9%)	15%	8%	6
Spr2012	14.2%	(13.6% 14.7%)	14%	1%	4	11.4%	(11.1% 11.6%)	11%	0%	3
Car 2012	16.0%	(15.0% 17.0%)	16%	1%	4	12.5%	(11.0% 13.0%)	13%	1%	4
Bed2012	22.4%	(14.3% 38.4%)	19%	9%	12	11.7%	(5.8% 23.0%)	10%	7%	12
Boh2012-3	17.0%	(17.0% 17.0%)	17%	0%	1	12.6%	(8.0% 16.0%)	14%	3%	9
Ant2012	13.5%	(13.5% 13.5%)	14%	0%	1	12.0%	(11.1% 12.9%)	12%	1%	2
Mat2009	4.0%	(4.0% 4.0%)	4%	0%	1	-1.8%	(-7.0% 1.0%)	0%	4%	5
McKW2009	7.5%	(4.0% 11.0%)	8%	5%	2	-22.5%	(-41.0% 22.5%)	-23%	26%	2
PS2007	26.5%	(25.0% 28.0%)	27%	2%	2	24.0%	(21.0% 27.0%)	24%	3%	4
KH2010	11.0%	(11.0% 11.0%)	11%	0%	1	9.0%	(8.0% 10.0%)	9%	1%	2
BabR2005	17.0%	(17.0% 17.0%)	17%	0%	1	16.0%	(16.0% 16.0%)	16%	0%	1
MM2004	24.2%	(0% 41%)	26%	11%	9	-4.5%	(-18.0% 9.0%)	-5%	19%	2
MQ2011-1	8.2%	(7.0% 11%)	8%	5%	10	-0.9%	(-4.2% 3.2%)	-1%	2%	10
DQ2005	13.0%	(13.0% 13.0%)	13%	0%	1	-1.0%	(-6.0% 4.0%)	-1%	7%	2
DQ2008	9.0%	(7.0% 11.0%)	9%	2%	3	-2.0%	(-2.0% 2.0%)	-2%	0%	3
MQ2011-2	10.4%	(10.4% 10.4%)	10%	0%	2	5.5%	(3.8% 7.1%)	2%	2%	4

Table 6: Summary statistics for studies. Output change for EITE industries

		No BCA					BCA				
	Sector	Mean	Range	Med	Std	Obs	Mean	Range	Med	Std	Obs
Boh2012	"EITE" (1)	-2.86%	(-5.20% -1.20%)	-2.8%	1.1%	13	-1.03%	(-3.00% -0.20%)	-0.9%	0.9%	13
Gho2012	"EITE" (1)	-5.66%	(-7.73% -3.58%)	-5.7%	2.4%	4	0.80%	(0.53%-0.94%)	0.9%	0.2%	4
AT2012	Own Average (7)	-1.83%	(-2.80% -1.00%)	-1.7%	0.9%	3	0.07%	(-0.10% 0.20%)	0.1%	0.2%	3
Lan2012	"EIT sectors" (2)	-2.17%	(-2.70% -1.90%)	-1.9%	0.5%	3	-0.45%	(-0.50% -0.30%)	-0.5%	0.1%	4
Boh2012-2	"EITE" (1)	-2.30%	(-4.95% -0.55%)	-2.2%	1.5%	9	-0.64%	(-1.29% -0.20%)	-0.6%	0.4%	9
Spr2012	"Energy-intensive goods (EIT) (3)	-2.01%	(-2.31% -1.77%)	-2.0%	2.2%	4	-0.27%	(-0.30% -0.23%)	-0.3%	0.0%	3
Car 2012	Own Average (6)	-3.20%	(-3.20% -3.20%)	-3.2%	0.0%	1					0
Mat2009	"Energy-intensive Manufacturing" (4)	-2.30%	(-2.30% -2.30%)	-2.3%	0.0%	5	-0.08%	(-1.50% 2.20%)	-0.3%	1.4%	5
McKW2009	"Non durables" (5)	-0.15%	(-0.20% -0.10%)	-0.2%	0.1%	2	-0.25%	(-0.30% -0.20%)	-0.3%	0.1%	2
PS2007	Own Average (6)	-0.40%	(-0.40% -0.40%)	-0.4%	0.0%	4	0.20%	(0.10%-0.30%)	0.2%	0.1%	4
KH2010	Own Average (8)	-2.00%	(-2.00% -2.00%)	0%	0.0%	2	-0.05%	(-0.60% 0.50%)	-0.1%	0.8%	2
BabR2005	"Energy Intensive Goods" (3)	-1.20%	(-1.20% -1.20%)	-1.2%	0.0%	1	-0.30%	(-0.30% -0.30%)	-0.3%	0	1
MM2004	Steel (only sector)	-7.10%	(-7.10% -7.10%)	-7.1%	0.0%	2	-3.05%	(-4.40% -1.70%)	-3.1%	1.9%	2
MQ2011-1	Own Average (9)	-7.86%	(-7.86% -7.86%)	-7.9%	0.0%	1	-6.41%	(-6.90% -5.80%)	-6.4%	0.4%	5
DQ2005	Cement (only sector)	-7.50%	(-7.50% -7.50%)	-7.5%	0.0%	2	-2.50%	(-3.00% -2.00%)	-2.5%	0.7%	2
DQ2008	Own Average (9)	-11.67%	(-19.00% 5.00%)	-11.7%	7.0%	3	-4.33%	(-7.00% -2.00%)	-4.3%	2.5%	3
MQ2011-2	Own Average (9)	-7.47%	(-7.47% -7.47%)	-7.5%	0.0%	1	-5.47%	(-6.40% -5.00%)	-5.2%	0.7%	4

(1) Aggregation of 5 sectors (Refined goods, Chemical products, Non-metallic minerals, Iron and Steel industry, Non-ferrous metals)
(2) Aggregation of 4 sectors: same as (1) except no Refined goods
(3) 1 sector in the model. Probably same as (2)
(4) Specific sectors non specified
(5) One sector
(6) Iron and Steel and Non Metallic Minerals
(7) Iron and Steel and Other Non Metallic Minerals
(8) Steel and Mineral Products
(9) Steel and Cement

Table 7: Summary statistics for studies. Welfare variation for the abating coalition

		No BCA					BCA				
		Mean	Range	Med	Std	Obs	Mean	Range	Med	Std	Obs
Boh2012	GDP	-0.40%	(-0.40% -0.40%)	-0.40%	0.00%	1	-0.40%	(-0.32% -0.32%)	-0.32%	0.00%	1
Gho2012	Welfare	-0.66%	(-1.58% -0.28%)	-0.54%	0.47%	6	-0.66%	(-0.89% -0.21%)	-0.35%	0.23%	12
AT2012	Welfare	-0.35%	(-0.62% -0.21%)	-0.33%	0.13%	27	-0.35%	(-0.50% -0.25%)	-0.28%	0.11%	27
Lan2012	Welfare	-0.17%	(-0.35% -0.01%)	-0.18%	0.09%	23	-0.01%	(-0.12% 0.09%)	-0.02%	0.04%	24
BalR2012	Welfare	-0.43%	(-0.85% 0.02%)	-0.60%	0.41%	5	-0.43%	(-0.2% -0.40%)	0.01%	0.21%	5
Wei2012	Welfare	-0.50%	(-0.50% -0.50%)	-0.50%	0.00%	1	-0.50%	(-0.4% -0.40%)	-0.40%	0.00%	1
BB2012	Welfare	-0.74%	(-0.88% -0.54%)	-0.79%	0.18%	3	-0.74%	(-0.81% -0.50%)	-0.77%	0.15%	6
Spr2012	Welfare	-0.51%	(-0.54% -0.44%)	-0.54%	0.06%	3	-0.51%	(-0.42% -0.36%)	-0.38%	0.03%	3
Boh2012-3	Welfare	-0.69%	(-0.69% -0.69%)	-0.69%	0.00%	1	-0.69%	(-0.66% -0.42%)	-0.56%	0.08%	9
Mat2009	Welfare	-0.60%	(-0.60% -0.60%)	-0.60%	0.00%	1	-0.60%	(-0.50% -0.40%)	-0.50%	0.04%	5
McKW2009	GDP	-0.60%	(-0.60% -0.60%)	-0.60%	0.00%	2	-0.60%	(-0.60% -0.60%)	-0.60%	0.00%	2
Win2011	Welfare	-0.92%	(-0.92% -0.92%)	-0.92%	0.00%	1	-0.92%	(-0.90% -0.79%)	-0.87%	0.04%	4
BabR2005	Welfare	-0.41%	(-0.41% -0.41%%)	-0.41%	0.00%	1	-0.41%	(-0.32% -0.32%)	-0.32%	0.00%	1